JC891 U.S. PTO
08/22/00

08-23-00

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Case Docket No. FUJR 17.570
Filed by Express Mail
(Receipt No. EL522338195US)
on August 22, 2000
pursuant to 37 CFR 1.10
by Lydia Gonzalez

THE COMMISSIONER OF PATENTS AND TRADEMARKS
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For ORDERWIRE CONTROLLER

JC880 U.S. PTO
09/643441
08/22/00

Enclosed are:

[X] 14 sheets of drawings.(Figs. 1-14)
[X] Specification, including claims and abstract (26 pages)
[X] Declaration
[X] An assignment of the Invention to FUJITSU LIMITED
[X] A certified copy of Japanese Application No(s). 11-305027
[X] An associate power of attorney
[ ] A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27
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TOTAL CLAIMS	9-20 =	0
INDEP CLAIMS	2-3 =	0
[ ] MULTIPLE DEPENDENT CLAIMS PRESENTED		

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SMALL ENTITY	
RATE	FEE
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X 39 =	$
x 130 =	$
TOTAL	$

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RATE	FEE
	$690
x 18 =	$
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x 260 =	$
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ORDERWIRE CONTROLLER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an orderwire controller and orderwire control system. More particularly, the present invention relates to an orderwire controller and system which control orderwire voice channels for use by maintenance people.

2. Description of the Related Art

Synchronous Digital Hierarchy (SDH) and Synchronous Optical Network (SONET) are standard specifications which provide core technologies to efficiently multiplex a wide variety of high-speed and low-speed services. In SDH/SONET systems, various control signals for operations and maintenance services are carried by a prescribed section of each transmission frame, called the "overhead." In particular, the overhead contains E1/E2 bytes for orderwire functions, with which maintenance people working at different network elements can talk to each other.

Normally, the orderwire communication is performed in broadcast mode, allowing one engineer to communicate with two or more other engineers simultaneously. In the case that the network is configured in a ring topology, the orderwire facilities offer ring protection functions to avoid howls, as well as providing ring restoration

capabilities to recover from link failure. FIGS. 10 and 11 are diagrams explaining the concept of ring protection functions. More specifically, FIG. 10 shows a situation where orderwire signals propagate over a loop, and FIG. 11 shows how such a loop can be avoided by using ring protection functions.

Referring first to FIG. 10, four network elements (NEs) 101 to 104 are connected in a ring topology. Those NEs 101 to 104 are each equipped with a mixer A1 to A4, which is an analog adder to combine multiple voice signals in analog form. Telephone sets 101-1 to 104-1 are attached to those NEs 101 to 104, respectively, through a transformer (not shown). A digital voice orderwire signal carried on the E1/E2 bytes is converted into an analog voice signal when it has reached an NE. That analog voice signal is then mixed with similar signals sent from other NEs, and the NE sends the resultant signal to its local telephone set 101-1 to 104-1. Each NE also receives an analog voice signal from its local telephone set 101-1 to 104-1. This signal is mixed with similar voice signals sent from other NEs, converted into a digital voice signal, and sent out to the adjacent NEs on the E1/E2 bytes of SONET/SDH frames. In this way, all the telephone sets 101-1 to 104-1 coupled to the NEs 101 to 104 are interconnected by a common orderwire circuit.

With the above-described construct alone, however, the orderwire circuit would make a loop in each ring

direction as indicated by the dotted lines in FIG. 10, where the outgoing signal transmitted from one telephone set comes back to itself after a certain propagation delay time. As a result, the speaker would hear the echo of his/her voice through the handset he/she is using, thus suffering an interference known as a howl.

To avoid the problem of howling noises, the NEs 101 to 104 are configured to operate under a mater-slave relationship in which the master station disconnects, or terminates, the orderwire circuit at its east or west side. FIG. 11 illustrates this master-slave configuration. In this example network, the NE 101 works as the master station, while other NEs 102 to 104 as slave stations. The master NE 101 terminates the orderwire circuit at its west ports, breaking the loop of orderwire signals. Now that the NEs 101 to 104 are interconnected in a linear fashion, the howling noise problem will never occur.

Referring next to FIGS. 12 and 13, the concept of ring restoration functions is depicted. More specifically, FIG. 12 shows a situation where a link failure occurs, and FIG. 13 shows how it is resolved by a ring restoration function.

In the system of FIG. 12, the NEs 101 to 104 form a ring network, the master NE 101 terminating its west-side orderwire circuit to avoid howling problems. Suppose here that a link failure occurs as indicated by the dotted circle in FIG. 12. Because of the presence of orderwire

termination at the west side of the NE 101, the NEs 101 and 102 cannot communicate with the other NEs 103 and 104 any longer. In such a situation, a link failure would disrupt the delivery of orderwire signals to some member NEs in the ring, as long as the orderwire circuit is terminated at the master NE.

To correct this situation, it is necessary to reconfigure the ring network so that the termination of the orderwire circuit will be removed, and to make this operation possible, the master NE 101 should be notified of the link failure. Referring now to FIG. 13, the NE 103 detects a link communication error and reports it to the master NE 101 via the intermediate NE 104. The master NE 101 then connects the orderwire at its west side, and simultaneously, the NE 103 terminates the orderwire circuit at its west side. The orderwire connection is now recovered from disruption.

While, in the above-described ring system, one network element belongs only to a single ring, there are some other systems where one network element is connected to two or more ring networks. The network element of this type is referred to herein as the "junction node." FIG. 14 illustrates a system where two ring networks meet at a junction node, NE 100. The NE 100 provides junction functions to support the two rings, ring-a and ring-b. More specifically, the ring-a is formed by four NEs 101 to 103, and the ring-b is formed by four NEs 100 and 201 to

203, the two rings sharing the NE 100 as an intermediary node between them.

Conventionally, the junction node NE 100 provides only one mixer for orderwire signaling, as other normal NEs have. That mixer unit does not support mixing of orderwire signals supplied from a plurality of ring networks. For this reason, the NE 100 should choose either ring-a or ring-b to make orderwire functions operable in such a conventional system. This means that the NE 100 has to disconnect (or terminate) the non-chosen orderwire circuit at both the east and west ports. In the system of FIG. 14, the ring-a orderwire circuit is disconnected as such. This conventional setup of orderwire circuits does not allow the ring-a to form a complete ring network in terms of orderwire signaling, while normal communication data can be transported among the NEs 100 to 103 over the ring-a. (Note that the above termination only applies to orderwire signals, but it does not affect other normal traffic signals.) The ring-b, on the other hand, enables its members to communicate with each other over the orderwire channel, enjoying the benefits of a ring protection and ring restoration functions described earlier. In the illustrated system, the NE 201 serves as the master station of ring-b, the other NEs 100, 202, and 203 being slave stations. The master 201 terminates the orderwire circuit at its west port.

To see what problems are inherent in the above-

described multi-ring network system, consider the orderwire communication between the NEs 101 and 103 on the ring-a, in comparison with that between the NEs 100 and 203 on the ring-b. Since the orderwire circuit on the ring-b forms a fully functional ring, its ring restoration capabilities are expected to work effectively to save the network from a possible fault. For example, if it encounters a link failure at a portion Pb as shown in FIG. 14, the ring-b restores the orderwire communication through the steps of: (1) detecting the failure Pb at the NE 100, (2) sending a link failure alarm from the slave NE 100 to the master NE 201, and (3) moving the orderwire termination from the west side of the master NE 201 to the east side of the NE 100. In contrast to the ring-b, the ring-a has a problem in its orderwire circuit. More specifically, suppose that a link failure has occurred at a portion Pa shown in FIG. 14. In this case, the NEs 101 and 103 can no longer communicate with each other because their orderwire signals are blocked at the NE 100 in both the east-bound and west-bound directions.

As seen from the above discussion, the conventional junction function implemented in the NE 100 is insufficient in terms of its tolerance to link failures, since it cannot fully support the rings. In other words, the conventional orderwire system has to pose functional limitations on some of the rings. In case of a link failure, the orderwire communication on such rings would

be inevitably disrupted, because of the lack of ring restoration functions.

Another problem in the conventional networks is that the NE 100 at the junction point lacks flexibility in the orderwire communication between different rings. The propagation of orderwire signals are confined within a single ring; there is no connectivity between the ring-a and ring-b. Thus, disadvantageously, the conventional networks fail to provide good usability or expandability of a system.

Still another problem in the conventional networks is that they cannot support orderwire communication between A-law systems (used in SDH networks) and Mu-law systems (used in SONET networks). When two ring networks use those different coding methods, they cannot communicate correctly because of the lack of appropriate conversion facilities.

SUMMARY OF THE INVENTION

Taking the above into consideration, an object of the present invention is to provide an orderwire controller with enhanced capabilities of orderwire signaling to provide improved usability and maintainability.

Another object of the present invention is to provide an orderwire control system with enhanced capabilities of orderwire signaling to provide improved

usability and maintainability.

To accomplish the first object, according to the present invention, there is provided an orderwire controller which controls orderwire circuits to provide maintenance people with voice communication facilities. This controller comprises: a plurality of mixers which mix orderwire signals together; and a combination controller which controls the combinations of the orderwire signals to be mixed.

To accomplish the second object, according to the present invention, there is provided an orderwire control system which controls orderwire circuits to provide maintenance people with voice communication facilities. This system comprises: (a) a plurality of ring networks in which a plurality of nodes are interconnected in a ring topology; and (b) an orderwire controller comprising: a plurality of mixers which mix orderwire signals together, and a combination controller which controls the combinations of the orderwire signals to be mixed.

The above and other objects, features and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the present invention by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a conceptual view of an orderwire

controller according to the present invention;

FIG. 2 is a diagram which shows a variation of combination control;

FIG. 3 is a diagram which shows a two-ring network system according to the present invention;

FIG. 4 is a diagram which shows the structure of a network element;

FIG. 5 is a diagram which shows the internal structure of a mixer and a telephone set interface;

FIG. 6 is a diagram which shows how a two-ring system deals with a link failure;

FIG. 7 is a diagram which shows a system configuration where two ring networks share their orderwire circuits;

FIG. 8 is a diagram which shows a system where ring networks using A-law coding are linked with those using Mu-law coding;

FIG. 9 is a diagram which shows a configuration of a digital code converter;

FIGS. 10 and 11 are diagrams which show the concept of ring protection functions;

FIGS. 12 and 13 are diagrams which show the concept of ring restoration functions; and

FIG. 14 is a diagram which shows a system where two ring networks meet at a junction node.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described below with reference to the accompanying drawings.

FIG. 1 is the conceptual view of an orderwire controller according to the present invention. This orderwire controller 10 is implemented in a network element (NE) to support voice communication between maintenance people over an orderwire circuit. The orderwire controller 10 comprises a plurality of mixers 1-1 to 1-n, combination controllers 2, and digital code converters 3. Each mixer 1-1 to 1-n is designed to add up, in a digital fashion, the orderwire signals supplied from a plurality of ring networks to which the NE belongs. Those mixers 1-1 to 1-n are coupled to appropriate ring networks through the combination controllers 2 and digital code converters 3 (described later). The ring networks may be SDH networks that transport signals in the form of Synchronous Transfer Module level four (STM-4), for example, but the invention should not be limited to any specific signal format.

In the illustrated system, there are a plurality of rings A to F, each of which comprises any number of member NEs. The NEs may each have a local telephone set to allow maintenance people to talk to each other, if necessary. While FIG. 1 depicts such specifics only for the ring A, the other rings also have similar structure. The mixers 1-1 to 1-n are properly allocated, so that they

serve the rings A to F in the following way:

- Mixer 1-1 serves the rings A and D,
- Mixer 1-2 serves the rings B and C,
- Mixer 1-3 serves the ring E, and
- Mixer 1-n serves the ring F.

The entire system comprising the proposed orderwire controller 10 and ring networks is referred to herein as the orderwire control system.

The combination controllers 2 comprise a matrix switch which provides flexible connections among the rings A to N and the mixers 1-1 to 1-n. That is, the combination controllers 2 can accept the orderwire signals from the rings A to F and direct them to any of the mixers 1-1 to 1-n, thereby providing a variety of mixing patterns as desired. With this mechanism, two or more rings can form a consolidated domain of orderwire communication. In the system of FIG. 1, the rings A and D share a single orderwire circuit, as do the rings B and C.

On the other hand, when a mixer is assigned to a single ring, the orderwire signal will be confined within that ring, meaning that a fully functional orderwire circuit can be formed. The rings E and F in the system of FIG. 1 are an example of this single ring arrangement. The most extreme case is when every ring needs an isolated orderwire circuit, in which case the orderwire controller 10 has to provide as many mixers as the number of rings.

The digital code converters 3 each convert an A-

law or Mu-law coded orderwire signal into a digital voice signal with unified quantizer step sizes. The resultant linear coded signals are supplied to the mixers 1-1 to 1-n through the combination controllers 2. Since the orderwire communication is bidirectional, the digital code converters 3 also convert a linear coded digital voice signal into either an A-law or Mu-law coded signal, depending the coding method used in a destination ring.

While FIG. 1 shows specific combinations of ring networks, the present invention is not restricted to those combinations. FIG. 2 shows a variation of the combination control, in which the combination controller 2 is programmed in such a way that all orderwire signals of the rings A to F will be concentrated to a single mixer 1-1. This arrangement permits all the NEs on the rings A to F to communicate with each other over a shared orderwire circuit.

Referring next to FIGS. 3 to 6, the following section will present a more specific system where the proposed orderwire controller 10 is placed at the junction point of two ring networks. What has been described above as the combination controller 2 is now called a "matrix switch."

FIG. 3 shows a two-ring system according to the present invention. Although it is not explicitly shown in FIG. 3, the proposed orderwire controller 10 is implemented in a network element 10a which provides

junction functions. The illustrated system comprises two rings, A and B. More specifically, the ring A is formed by four NEs 10a, 21, 22, and 23, and the ring B is formed by four NEs 10a, 31, 32, and 33. The two rings share the NE 10a as the junction node located therebetween. All those NEs are equipped with a local telephone set for maintenance purposes. The proposed orderwire controller 10 in the NE 10a can be configured as a master or slave station independently for each ring. Specifically, in the illustrated system of FIG. 3, the NE 10a serves as a slave station at both sides, A and B.

Each NE 21 to 23 on the ring A has a mixer for combining orderwire signals, as do the NEs 31 to 33 on the ring B. The NE 10a has two mixers 1-1 and 1-2 to support the rings A and B, respectively. Accordingly, both rings A and B have a fully functional orderwire circuit with ring protection and restoration functions. The NE 21 serves as the mater station on the ring A, as does the NE 31 on the ring B. Both master NEs 21 and 31 are configured to terminate their respective orderwire circuits at their west port.

FIG. 4 shows the internal structure of the NE 10a. Overhead demultiplexers 4-1 to 7-1 terminate the overhead of incoming SDH/SONET frames. To this end, the overhead demultiplexers 4-1 to 7-1 comprise failure detectors 4a to 7a and E1/E2 setting units 4b to 7b, respectively. The failure detectors 4a to 7a detect link failure. The E1/E2

setting units 4b to 7b determine which to use E1 byte or E2 byte for orderwire signaling, and whether to enable or disable the orderwire function itself.

Overhead multiplexers 4-2 to 7-2 insert overhead information to each SDH/SONET frame to be transmitted. To this end, the overhead multiplexers 4-2 to 7-2 comprise alarm insertion units 4c to 7c and E1/E2 setting units 4d to 7d, respectively. The alarm insertion units 4c to 7c insert a link failure alarm when a link failure is detected. The E1/E2 setting units 4d to 7d determine which to use E1 byte or E2 byte for orderwire signaling, and whether to enable or disable the orderwire function itself.

Digital code converters 3a, 3c, 3f, and 3h receives orderwire signals from the overhead demultiplexers 4-1 to 7-1 and convert them into linear coded digital voice signals with unified quantizer step sizes. The resultant signals are supplied to matrix switches 2a and 2b, which feed the signals to the mixers 1-1 and 1-2, appropriately controlling the cross-connections between their inputs and outputs. The matrix switches 2a and 2b also accept digital voice signals from the mixers 1-1 and 1-2 and redirect them to digital code converters 3b, 3d, 3e, and 3g. Those digital code converters 3b, 3d, 3e, and 3g each convert a given linear coded signal into an A-law or Mu-law coded orderwire signal. The resultant signals are supplied to their associated overhead multiplexers 4-2 to 7-2. A telephone

set interface 8, coupled to the mixers 1-1 and 1-2, controls connection to an external telephone set 10a-1.

FIG. 5 is a diagram showing the internal structure of the mixers 1-1 and 1-2 and the telephone set interface 8. The mixer 1-1 is composed of digital adders 1a to 1e. The mixer 1-2 is composed of digital adders 1f to 1j. Numerals in parentheses indicate the sources and destinations of orderwire signals. Signal (1), for example, is supplied from the matrix switch 2a and distributed to the digital adders 1a, 1c, 1d, and 1e in the mixer 1-1. Other signals (2) to (4) are distributed similarly.

The transmit voice signal produced in the telephone set 10a-1 is delivered to the ring B through the east and west ports of the NE 10a. The receive voice signals come in from the ring B through the east and west ports, which are supplied to the telephone set 10a-1 via a telephone set interface 8. This telephone set interface 8 comprises the following components: a transformer 8a, an A/D converter 8b, a D/A converter 8c, digital code converters 3i and 3j, and a selector 8d. The transformer 8a is a hybrid circuit which is used to convert from 2-wire interface to 4-wire interface and vice versa, besides supplying electric power. The A/D converter 8b receives an analog signal from the transformer 8a and converts it into digital form. The digital code converter 3i then converts that digital signal to a linear coded signal and sends it to the selector 8d. The selector 8d selects the

destination of the signal, either the mixer 1-1 or the mixer 1-2.

The selector 8d also receives digital signals from the mixers 1-1 and 1-2. It selects either one of those signals and supplies the selected signal to the digital code converter 3j. The digital code converter 3j then converts the digital signal to an A-law coded or Mu-law coded signal and passes it to the D/A converter 8c. The D/A converter 8c converts the received digital signal into an analog signal, which is supplied to the transformer 8a.

When no link failure is assumed, the network system of FIG. 3 will operate as follows. In the illustrated situation, the orderwire circuit is closed within each ring. The NE 21 serves as the master station on the ring A, disabling the use of E1/E2 bytes at its west port to prevent howls from happening. Similarly, the NE 31 serves as the master station on the ring B, disabling the use of E1/E2 bytes at its west port. The NE 10a is configured not to allow the two rings A and B to exchange their orderwire signals; its internal matrix switches 2a and 2b provide straight connections between the ring A and the mixer 1-1, and between the ring B and the other mixer 1-2.

For illustrative purposes, a specific orderwire link between the NE 21 and NE 23 will be discussed below. It is also assumed that the ring A transports STM-4 frames; i.e., four STM-1 frames #1 to #4 are time-division

multiplexed. At the NE 21, the voice signal originating from the telephone set 21-1 is processed in the mixer of the NE 21 and then inserted to the E1#1 byte of STM-4 traffic. This orderwire signal reaches the NE 23 via the NE 22. The NE 23 terminates the E1#1 byte of each STM-4 frame and sends out the received orderwire signal to its local telephone set 23-1 through its internal mixer. In the opposite direction, the orderwire signal is sent from the NE 23 to the NE 21 via the NE 22, being carried on the E1#1 byte. The NE 21 terminates the E1#1 byte to extract an incoming orderwire signal. In this way, the orderwire communication is accomplished between the two NEs 21 and 23.

Now consider the orderwire link between the NE 10a and NE 33 on the ring B, assuming that the ring B transports STM-4 frames. At the NE 10a, the voice signal originating from the telephone set 10a-1 passes through the mixer 1-2 in the NE 10a and is then inserted to the E1#1 byte of STM-4 traffic. This orderwire signal propagates over the ring B, finally reaching the destination NE 33. The NE 33 terminates the E1#1 byte of each STM-4 frame and sends out the received orderwire signal to its local telephone set 33-1 through the mixer. Similarly the orderwire signal is sent in the opposite direction, from the source NE 33 to the destination NE 10a. The NE 10a terminates the E1#1 byte to extract an incoming orderwire signal. In this way, the orderwire communication

is accomplished between the two NEs 10a and 33.

While the normal operations of the system have been explained above, the following section will discuss the behavior in a fault situation. Suppose that the proposed two-ring system has encountered a link failure at the point Pa as indicated by the dotted circle in FIG. 6. This link failure causes the nearest NE 22 to alarm the master NE 21 of the ring A about the link failure. To resolve this problem situation, the master NE 21 triggers its ring restoration function, which enables the use of E1/E2 bytes at its own west port, as well as making the NE 22 terminate the orderwire circuit at the east port.

Now that the orderwire circuit has been restored, the voice signal originating from the telephone set 21-1 passes through the mixer in the NE 21 and then is inserted to, for example, the E1#1 byte of STM-4 frames. This orderwire signal propagates toward the NE 23 over the ring A. The NE 23 terminates the E1#1 byte of each STM-4 frame and sends the received orderwire signal to the telephone set 23-1 through its own internal mixer. Likewise, the voice signal originating from the NE 23 reaches the destination NE 21 via the NE 10a, tracking the same path in the reverse direction. In this way the orderwire communication channel between the two NEs 21 and 23 can be maintained, despite of the link failure. The same mechanism would work in the ring B; the explanation will not be repeated here.

Referring next to FIG. 7, the following section will describe how the rings A and B share the same orderwire circuit. For illustrative purposes, a particular group of nodes (NEs 21, 23, 10a and 33) will be considered.

In the system of FIG. 7, the NEs 21 and 31 serve as the master station on the rings A and B, respectively, disabling the use of E1/E2 bytes at their west port to prevent howls from happening. To enable the two rings A and B to exchange their orderwire signals, the NE 10a is configured so that the internal matrix switches 2a and 2b will connect both rings to the mixer 1-1. The signal of the telephone set 10a-1 is also directed to the mixer 1-1 via the selector 8d (FIG. 5).

The voice signal originating from the telephone set 21-1 is fed to a mixer in the NE 21 and inserted to, for example, the E1#1 byte of STM-4 frames. This orderwire signal reaches the NE 23 via the NE 22. Terminating the E1#1 of incoming STM-4 frames, the NE 23 supplies its local telephone set 23-1 with the received orderwire signal through the internal mixer. The NE 23 also forwards the orderwire signal to the next NE 10a through its east port, mixing with its local voice signal and inserting that data to the E1#1 byte of outgoing STM-4 frames.

The NE 10a receives the STM-4 frames at its west port, terminating their E1#1 byte. The received orderwire signal is supplied to the telephone set 10a-1 through the mixer 1-1. The NE 10a also sends that orderwire signal to

the NE 33 through its east port on the ring B, mixing with its local voice signal and inserting that data to the E1#1 byte of outgoing STM-4 frames. The NE 33 receives those STM-4 frames at its west port, terminating their E1#1 byte. The received orderwire signal is supplied to the telephone set 33-1 through a mixer in the NE 33. In this way, the orderwire voice signals propagate from the NE 21 to the NE 33. The orderwire circuit also carries voice signals in the opposite direction (i.e., NE 33-->NE 10a-->NE 23-->NE 22) in a similar way, although it will not be explained here.

Referring next to FIG. 8, the following section will now describe a system where ring networks using the A-law coding method are linked with other ring networks using the Mu-law coding method.

In the illustrated system, the mixer 1-1 serves the rings A and D, and the mixer 1-2 serves the rings B, C, E, and F, under the cross connection control of the matrix switches 2a and 2b. With this setup, the two rings A and D share a common domain of orderwire signaling, as do the other rings B, C, E, and F. Note that the rings A, B, and E use A-law coding, while the rings C, D, F use Mu-law coding. The digital code converters 3 convert A-law or Mu-law coded orderwire signals into linear coded signals before supplying them to the mixers 1-1 to 1-n. This signal conversion permits the mixers 1-1 and 1-2 to perform digital summation directly, assuming that all the

input signals are linear coded. It is therefore possible for the NEs on different rings to communicate with each other, no matter which coding method they actually use, A-law or Mu-law.

FIG. 9 shows the structure of the digital code converter 3. The digital code converter 3 comprises an A-law/linear converter 30a, a Mu-law/linear converter 30b, and a switch 30c. The A-law/linear converter 30a converts A-law coded signals into linear coded signals and vice versa. Likewise, the Mu-law/linear converter 30b converts Mu-law coded signals into linear coded signals and vice versa. The switch 30c selects either one of the A-law/linear converter 30a and Mu-law/linear converter 30b on demand.

The above conversion mechanism is used as follows. When an A-law coded signal Sa is given, the switch 30c selects the output of the A-law/linear converter 31, thereby providing a linear coded signal Sb. When a linear coded signal Sc is given, and an A-law coded output is needed, the switch 30c chooses the A-law/linear converter 30a. The A-law/linear converter 30a then converts the given signal Sc to an A-law coded signal Sd. In this way, the digital code converter 3 converts an A-law or Mu-law coded orderwire signal into a linear coded signal, or vise versa. This enables the orderwire facilities to function correctly even when the network system involves both A-law based rings (SDH) and Mu-law based rings (SONET).

The above discussion will now be summarized as follows. According to the present invention, the orderwire controller 10 comprises a plurality of mixers 1-1 to 1-n which add up orderwire signals together, and a combination controller 2 which controls the combinations of the orderwire signals to be mixed by providing appropriate cross connections. In multi-ring network systems, the proposed orderwire controller 10 enables each ring to have a fully functional orderwire circuit that is tolerant to link failures, thus providing improved usability and maintainability. Further, according to the present invention, the mixers 1-1 to 1-n are implemented with digital adders, which can be integrated into a small chip at lower costs. Because of their high noise immunity, the digital mixers can provide more channels for simultaneous orderwire communication.

The foregoing is considered as illustrative only of the principles of the present invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and applications shown and described, and accordingly, all suitable modifications and equivalents may be regarded as falling within the scope of the invention in the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. An orderwire controller which controls orderwire circuits to provide maintenance people with voice communication facilities, comprising:

a plurality of mixing means for mixing orderwire signals together; and

combination control means for controlling combinations of the orderwire signals to be mixed.

2. The orderwire controller according to claim 1, further comprising digital code conversion means for performing signal conversion between an A-law coded or Mu-law coded orderwire signal and a linear coded digital voice signal.

3. The orderwire controller according to claim 1, wherein said plurality of mixing means add up the orderwire signals in a digital fashion.

4. The orderwire controller according to claim 1, wherein said plurality of mixing means mix the orderwire signals sent from network elements in at least one ring network.

5. The orderwire controller according to claim 4, wherein said combination control means controls

the combinations in such a way that the orderwire signals produced in each ring network will be closed within said each ring network.

6. The orderwire controller according to claim 4, wherein said combination control means controls the combinations in such a way that the orderwire signals produced in two ring networks will be shared by said two ring networks.

7. An orderwire control system which controls orderwire circuits to provide maintenance people with voice communication facilities, comprising:

(a) a plurality of ring networks in which a plurality of nodes are interconnected in a ring topology; and

(b) an orderwire controller comprising:

a plurality of mixing means for mixing orderwire signals together, and

combination control means for controlling combinations of the orderwire signals to be mixed.

8. The orderwire control system according to claim 7, wherein said combination control means controls the combinations in such a way that the orderwire signals produced in each ring network will be closed within said each ring network.

9. The orderwire control system according to claim 7, wherein said combination control means controls the combinations in such a way that the orderwire signals produced in two ring networks will be shared by said two ring networks.

ABSTRACT OF THE DISCLOSURE

An orderwire controller and orderwire control system which provide enhanced capabilities of flexible orderwire signaling to improve usability and maintainability. A network system involves multiple ring networks, each of which comprises a plurality of network elements interconnected in a ring topology. An orderwire controller, implemented in a network element, comprises a plurality of mixers and a combination controller. The mixers add up orderwire signals from local and remote sources. The combination controller controls how to associate the mixers with the rings, to provide flexible connections among the rings so that they can share their orderwire signals.

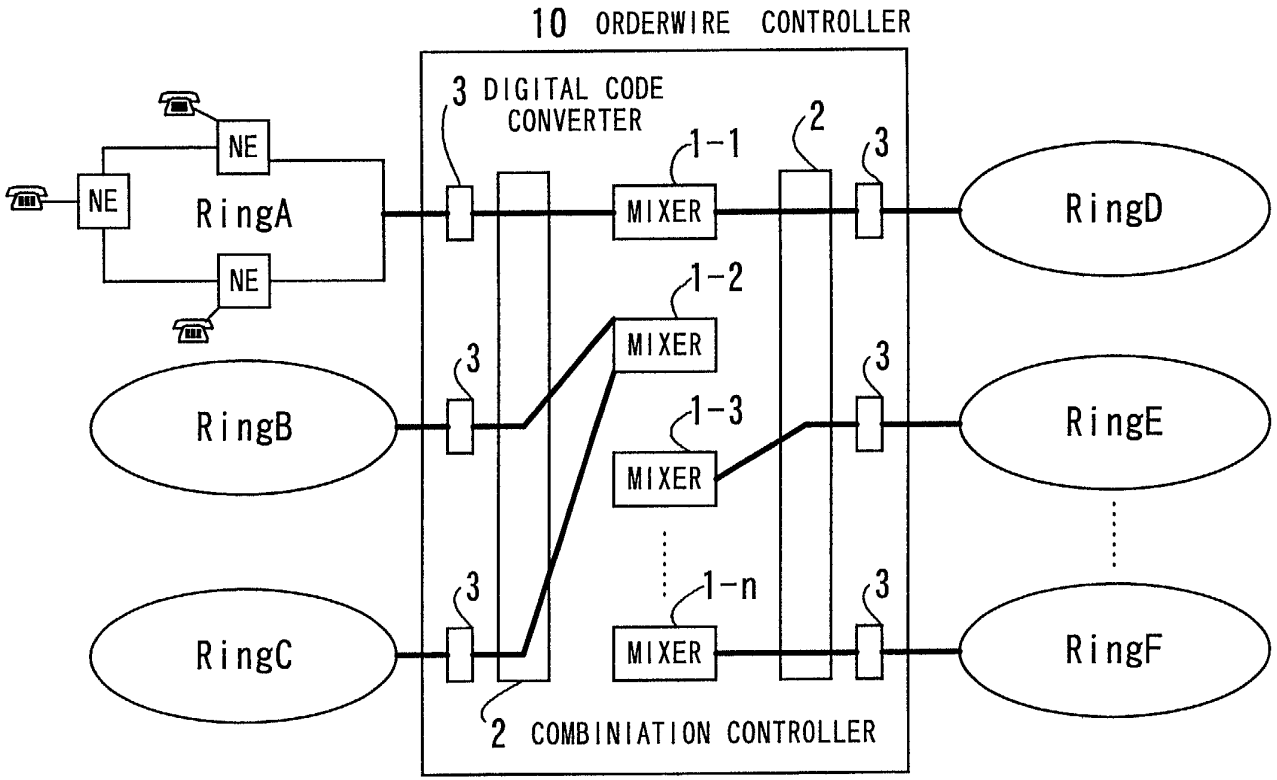
10 ORDERWIRE CONTROLLER
3 DIGITAL CODE CONVERTER
1-1
2
3
NE
NE
NE
RingA
MIXER
RingD
1-2
MIXER
3
3
RingB
1-3
MIXER
RingE
1-n
3
3
RingC
MIXER
RingF
2 COMBINIATION CONTROLLER

FIG. 1

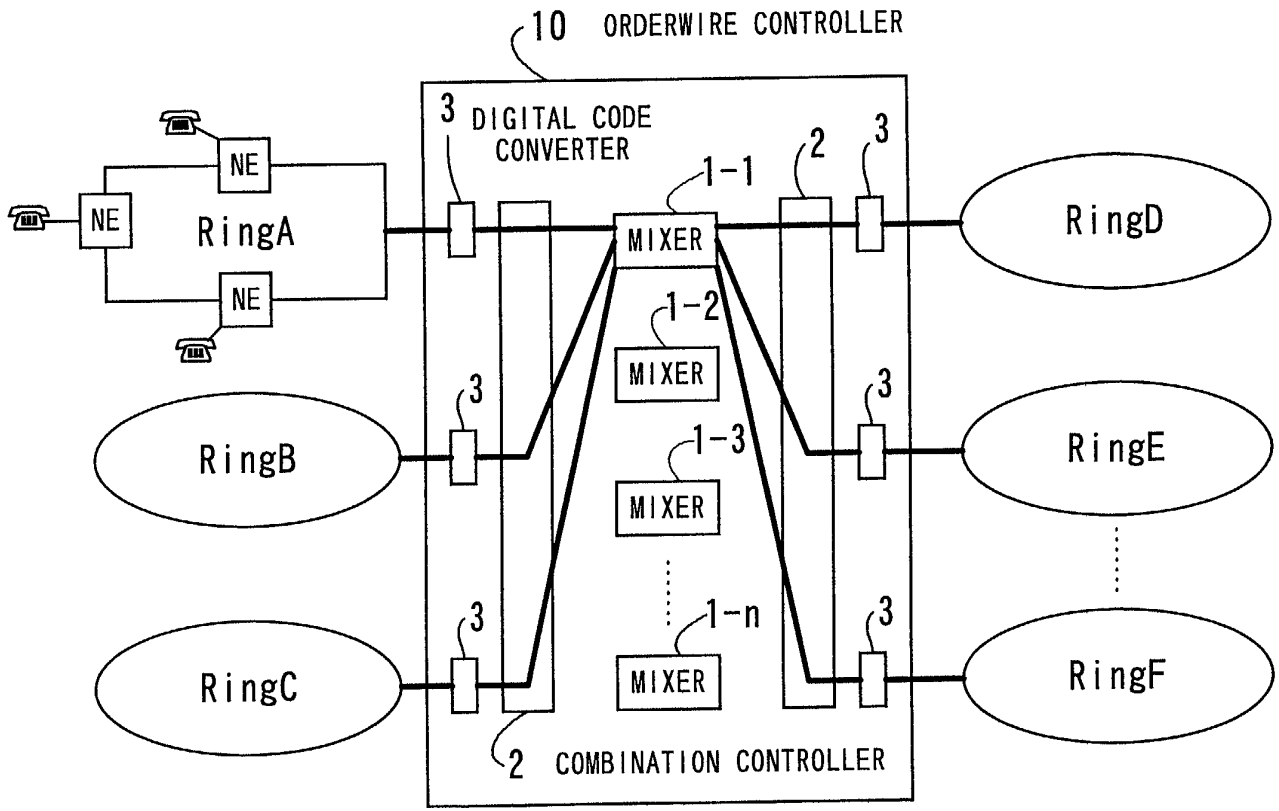
10 ORDERWIRE CONTROLLER
3 DIGITAL CODE CONVERTER
1-1
2
3
MIXER
1-2
MIXER
1-3
MIXER
1-n
MIXER
NE
NE
NE
RingA
RingB
RingC
RingD
RingE
RingF
2 COMBINATION CONTROLLER

FIG. 2

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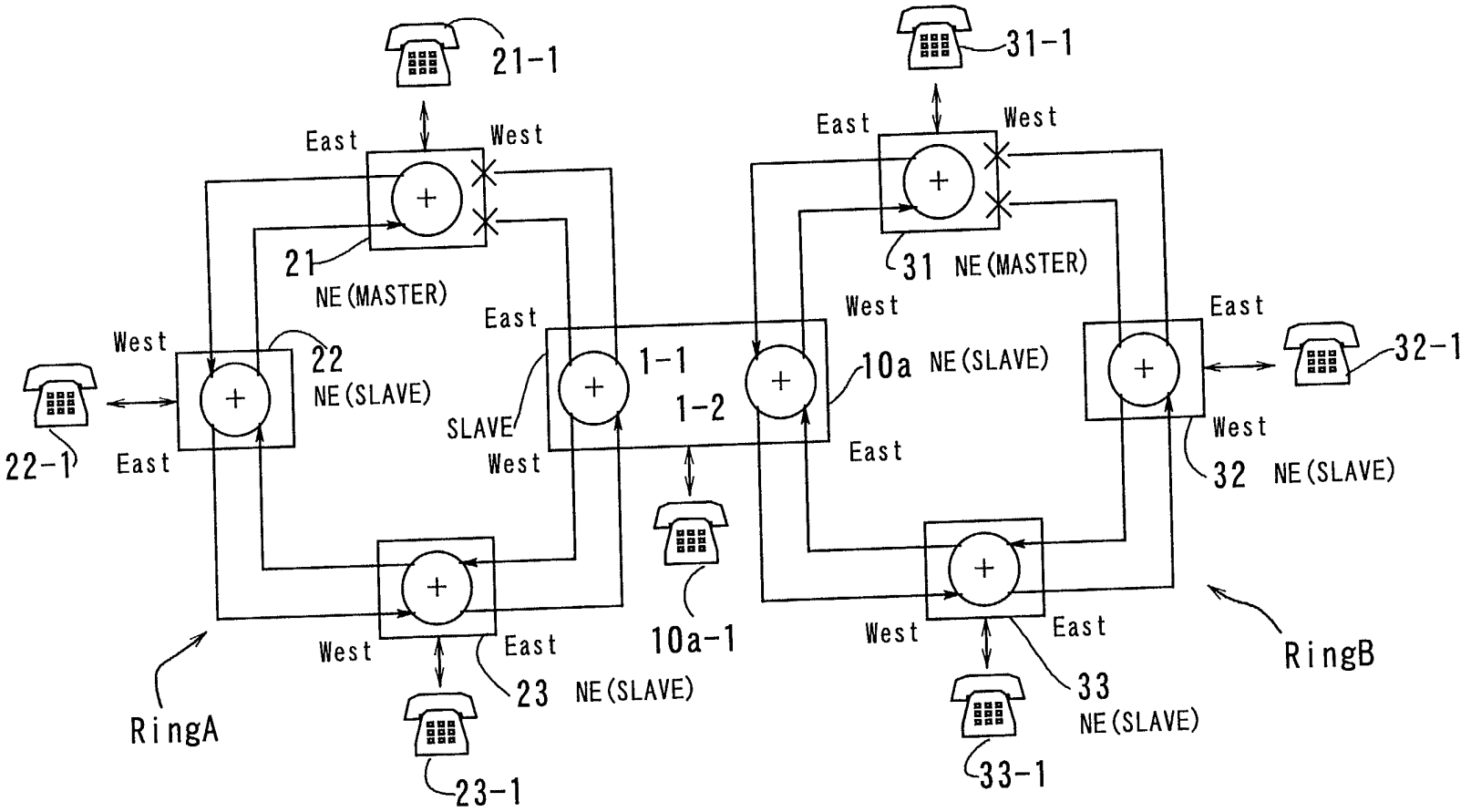

FIG. 3

002280 THHEH960

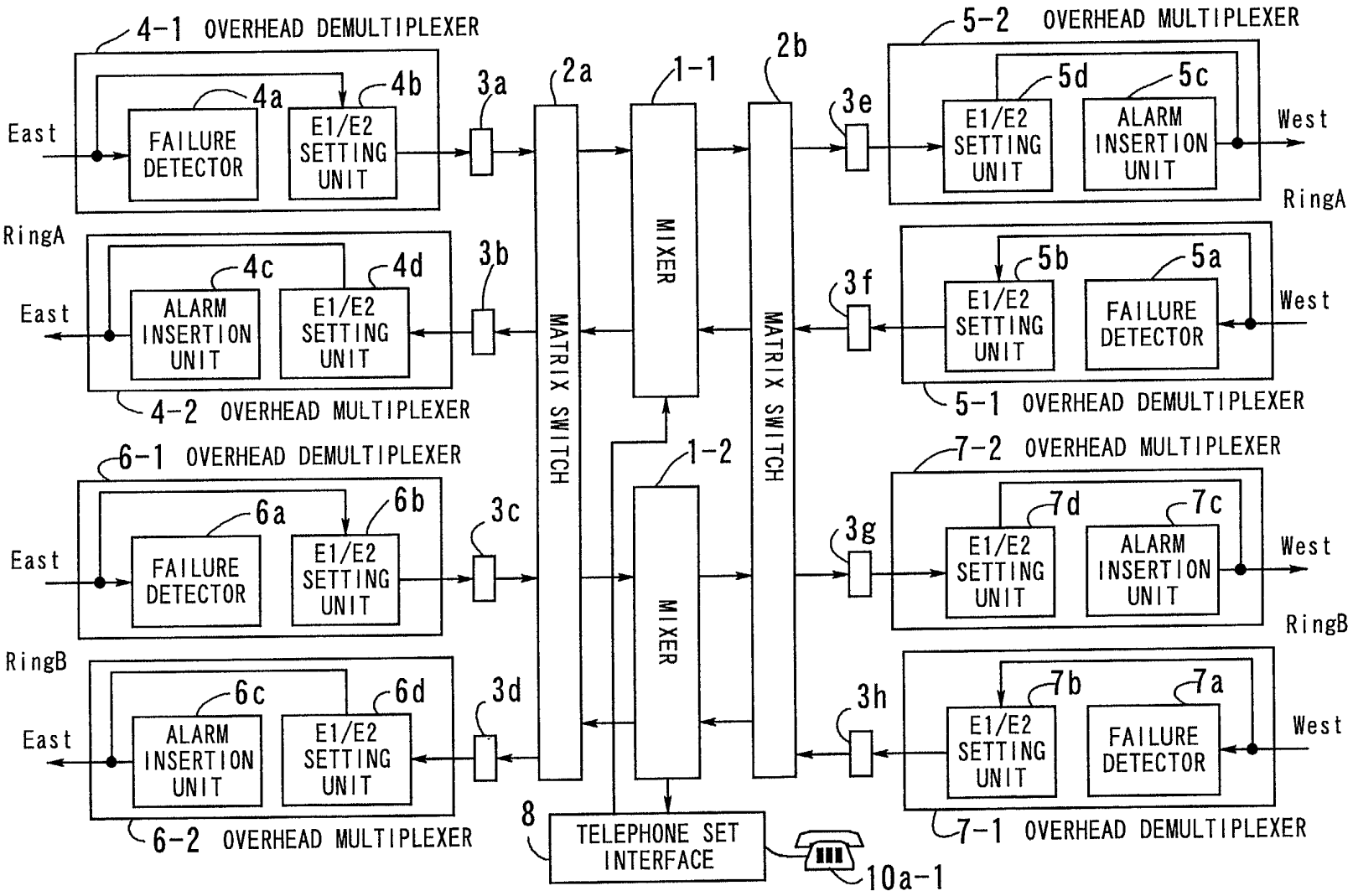

FIG. 4

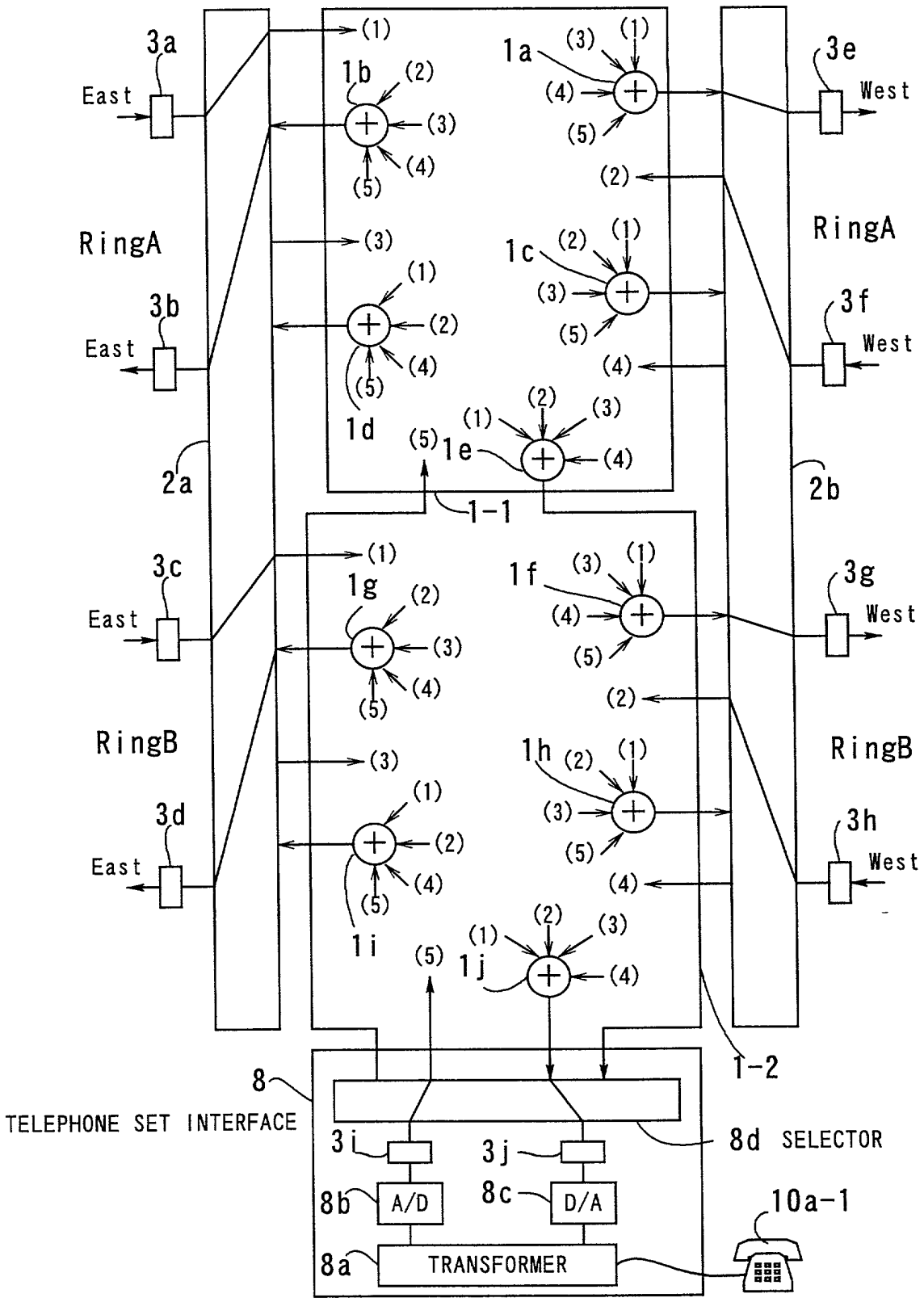
3a
East
(1)
1b
(2)
(3)
(4)
(5)
1a
(3)
(1)
(4)
(5)
3e
West
(2)
RingA
(3)
1c
(2)
(1)
(3)
(5)
3b
East
(1)
(2)
(4)
(5)
1d
3f
West
(4)
(2)
(1)
(3)
(5)
1e
(4)
2a
2b
1-1
3c
East
(1)
1g
(2)
(3)
(4)
(5)
1f
(3)
(1)
(4)
(5)
3g
West
(2)
RingB
(3)
1h
(2)
(1)
(3)
(5)
3d
East
(1)
(2)
(4)
(5)
1i
3h
West
(4)
(2)
(1)
(3)
(5)
1j
(4)
1-2
8
TELEPHONE SET INTERFACE
3i
3j
8d SELECTOR
8b
A/D
8c
D/A
10a-1
8a
TRANSFORMER

FIG. 5

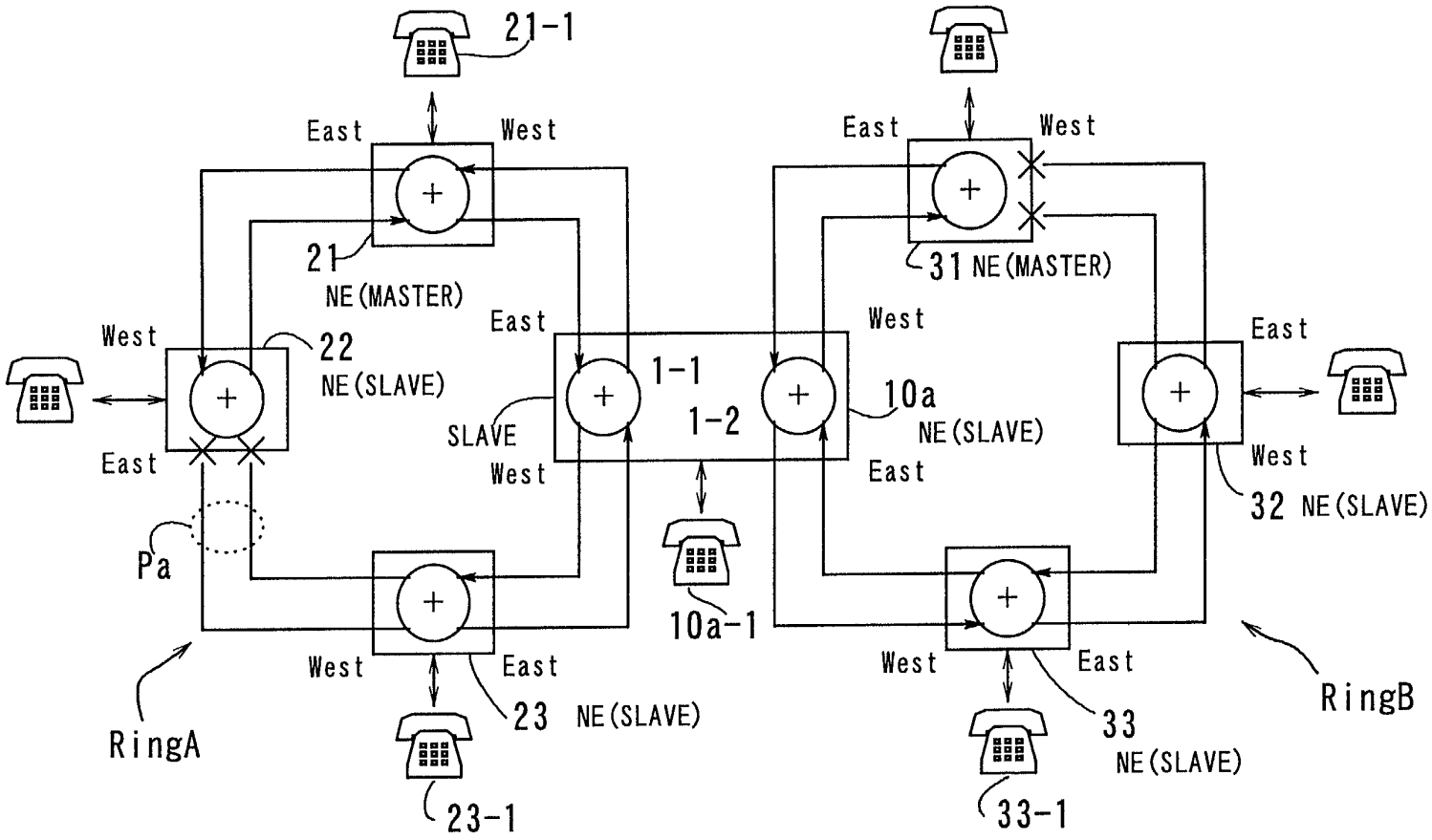
21-1
East
West
21
NE(MASTER)
West
22
NE(SLAVE)
East
Pa
RingA
West
East
23 NE(SLAVE)
23-1
East
SLAVE
West
1-1
1-2
10a-1
West
East
10a
NE(SLAVE)
East
West
31 NE(MASTER)
East
West
32 NE(SLAVE)
West
East
33
NE(SLAVE)
33-1
RingB

FIG. 6

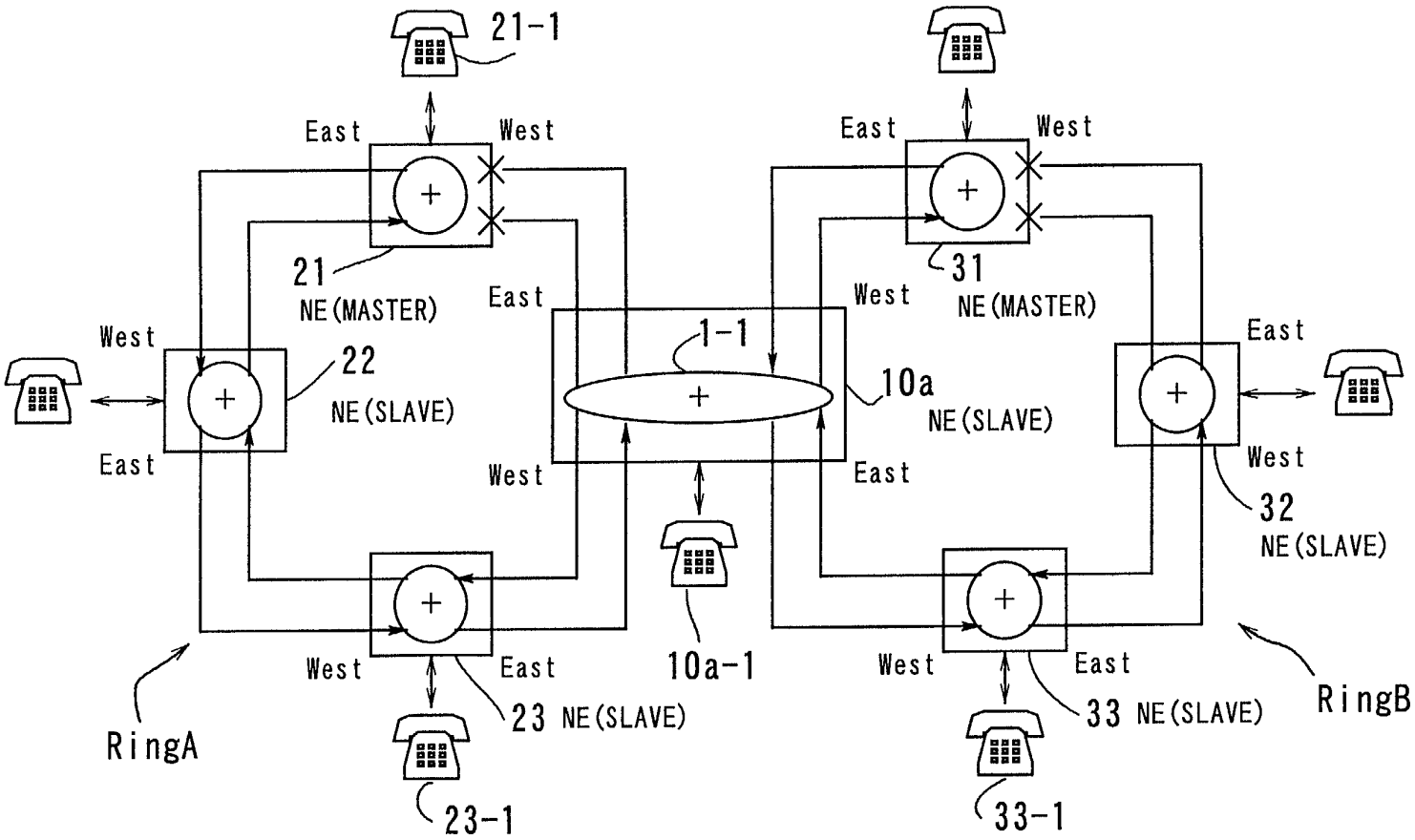
21-1
East
West
21
NE(MASTER)
West
East
22
NE(SLAVE)
East
West
1-1
10a
NE(SLAVE)
West
East
10a-1
West
East
23 NE(SLAVE)
23-1
RingA
East
West
31
NE(MASTER)
West
East
East
West
32
NE(SLAVE)
West
East
33 NE(SLAVE)
33-1
RingB

FIG. 7

002280 Thh2h960

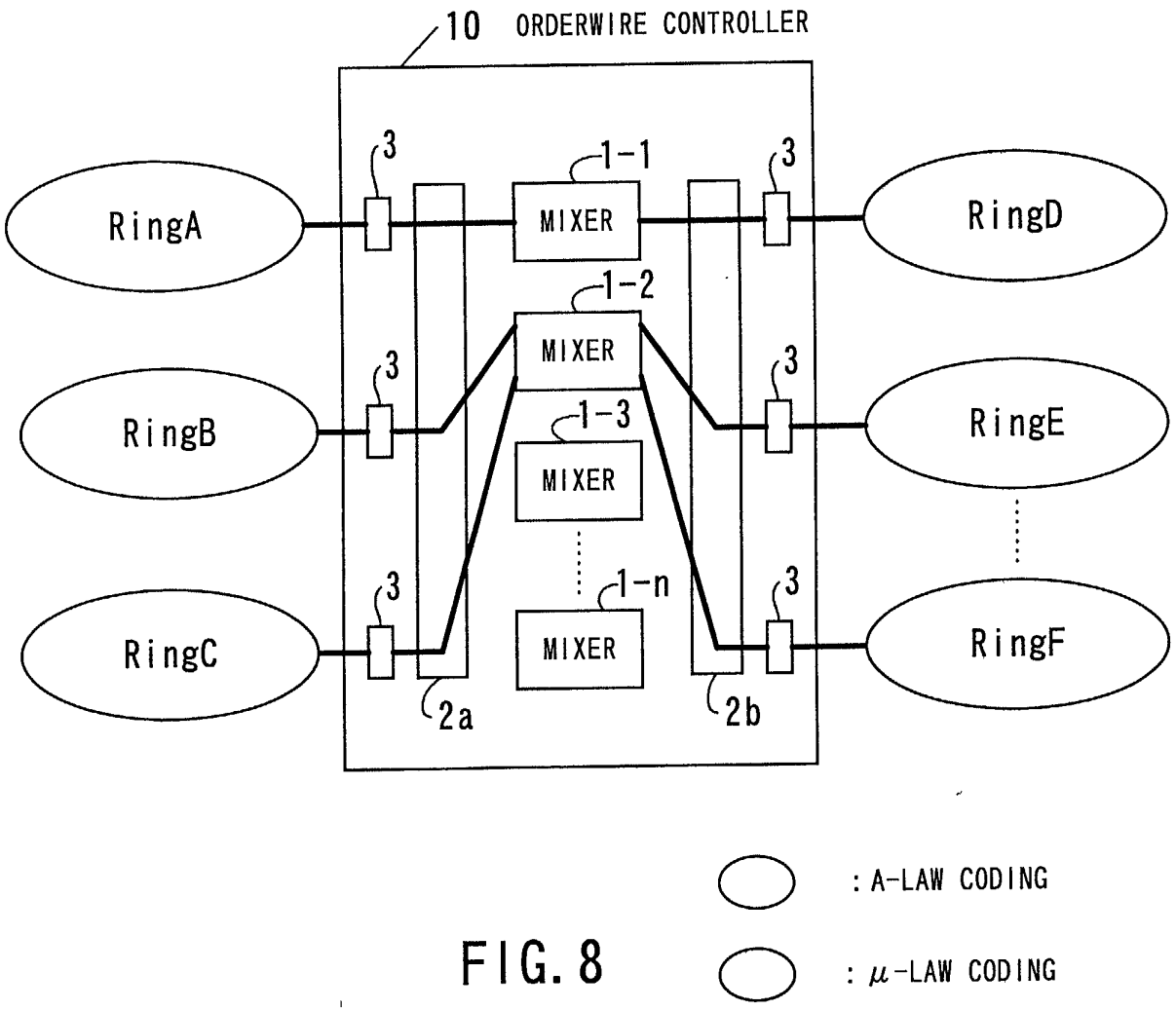

FIG. 8

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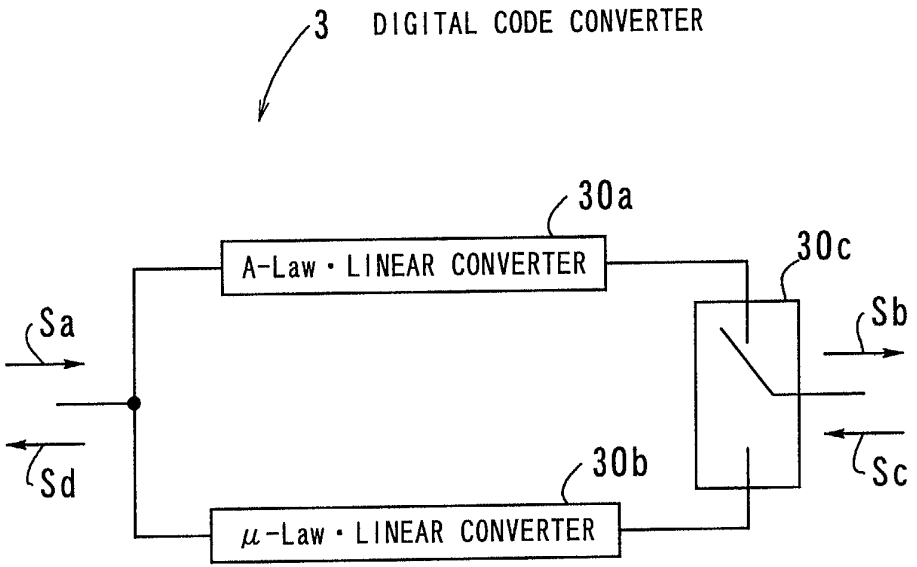

FIG. 9

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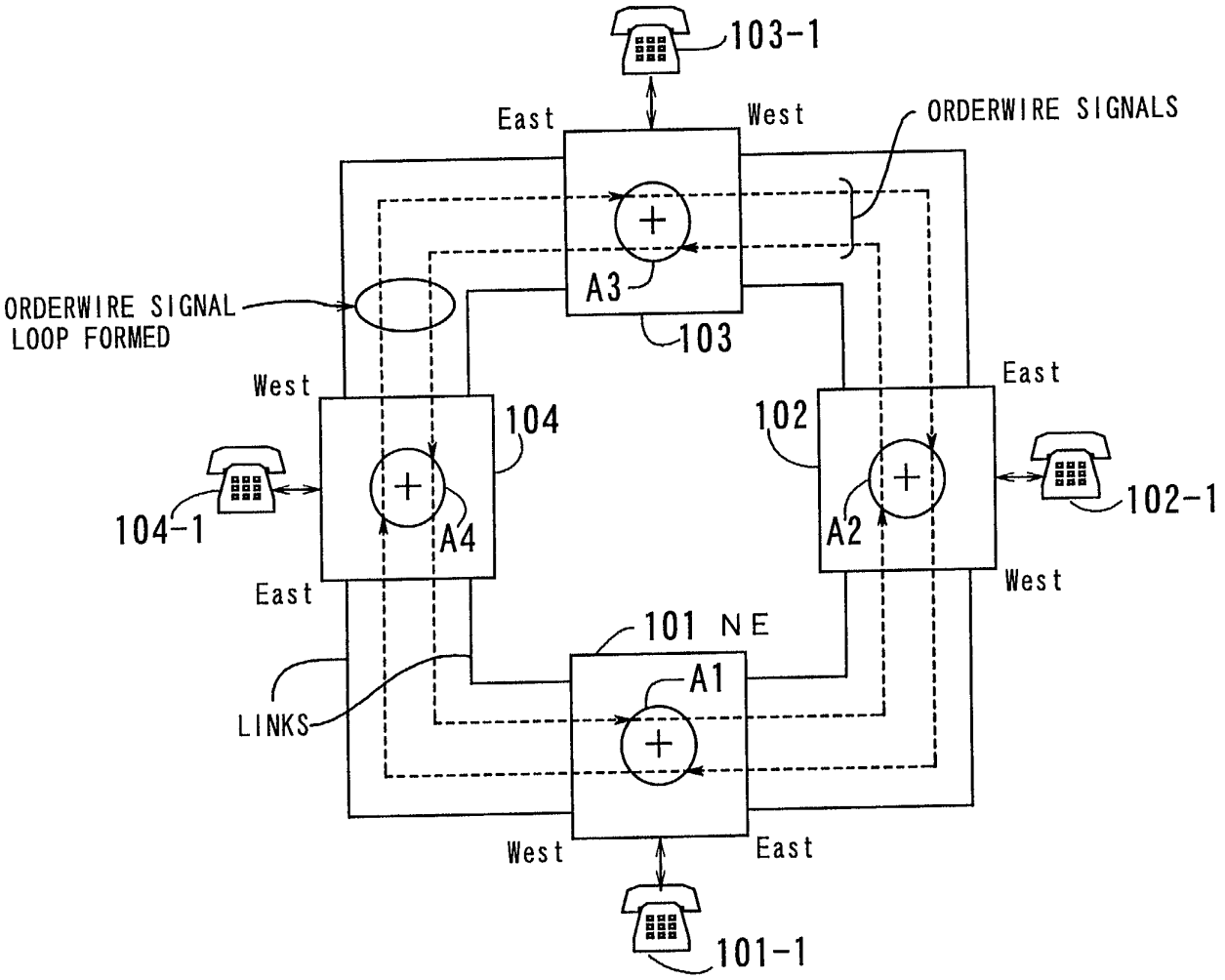
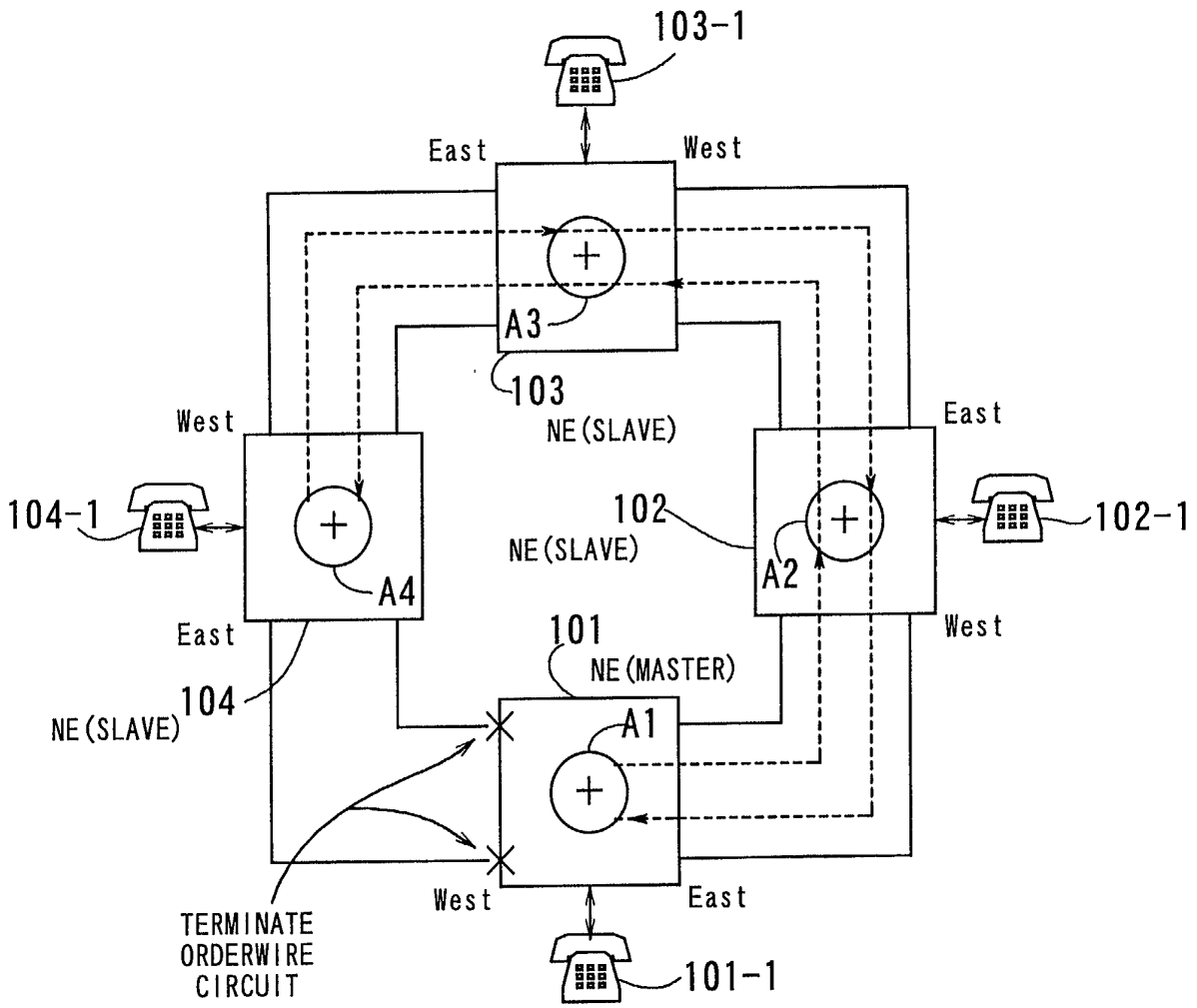
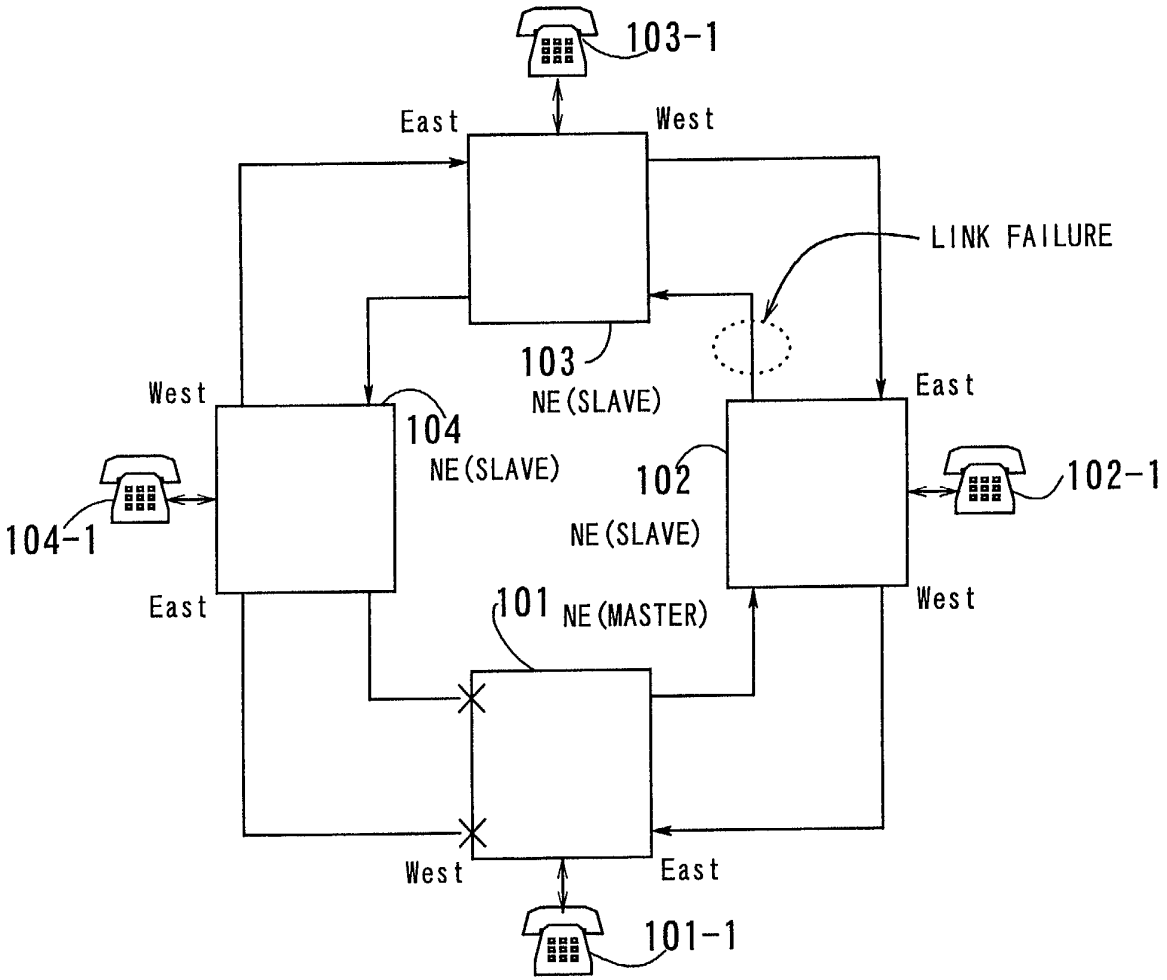


PRIOR ART
FIG. 10



PRIOR ART
FIG. 11



PRIOR ART
FIG. 12

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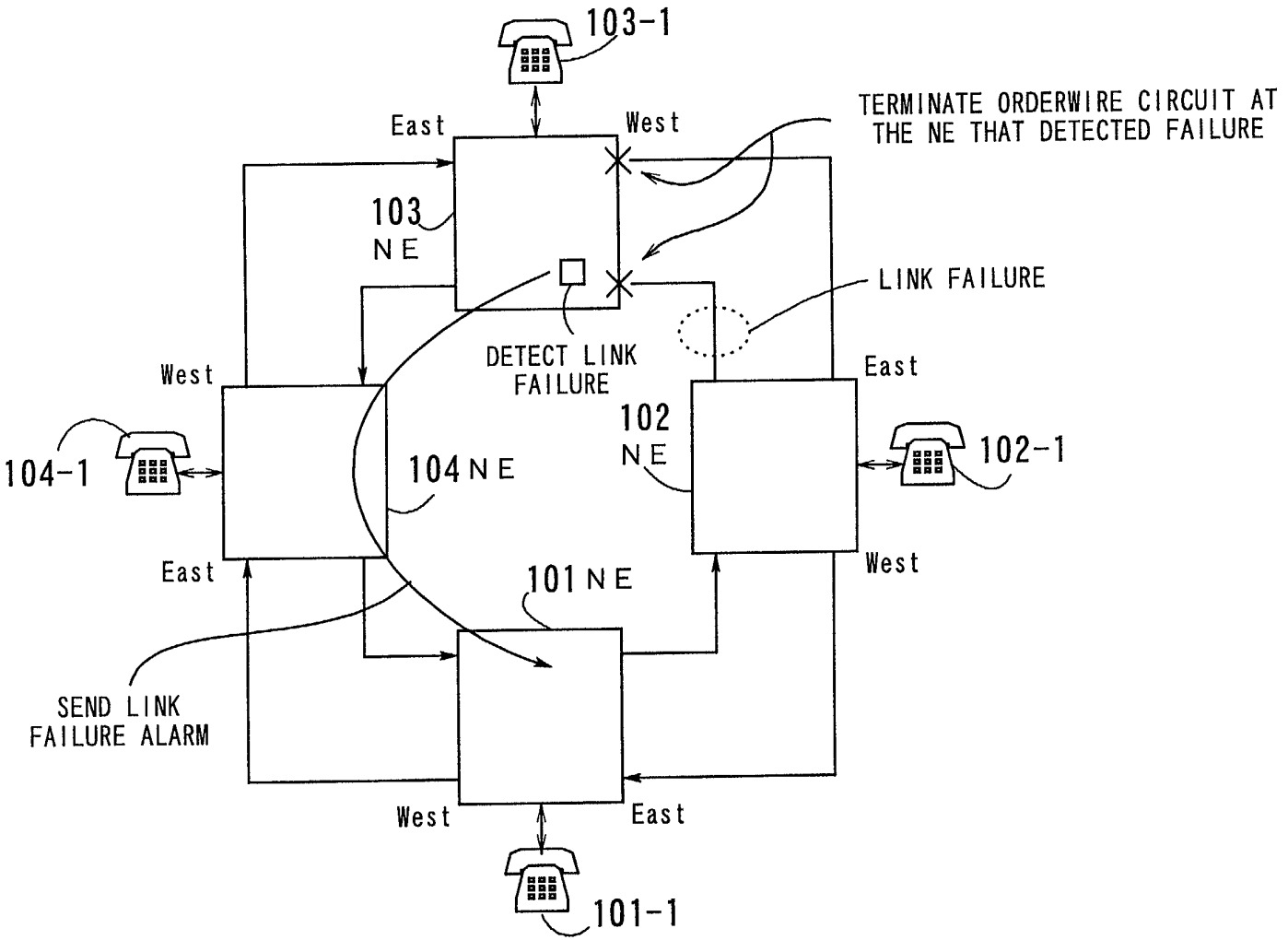
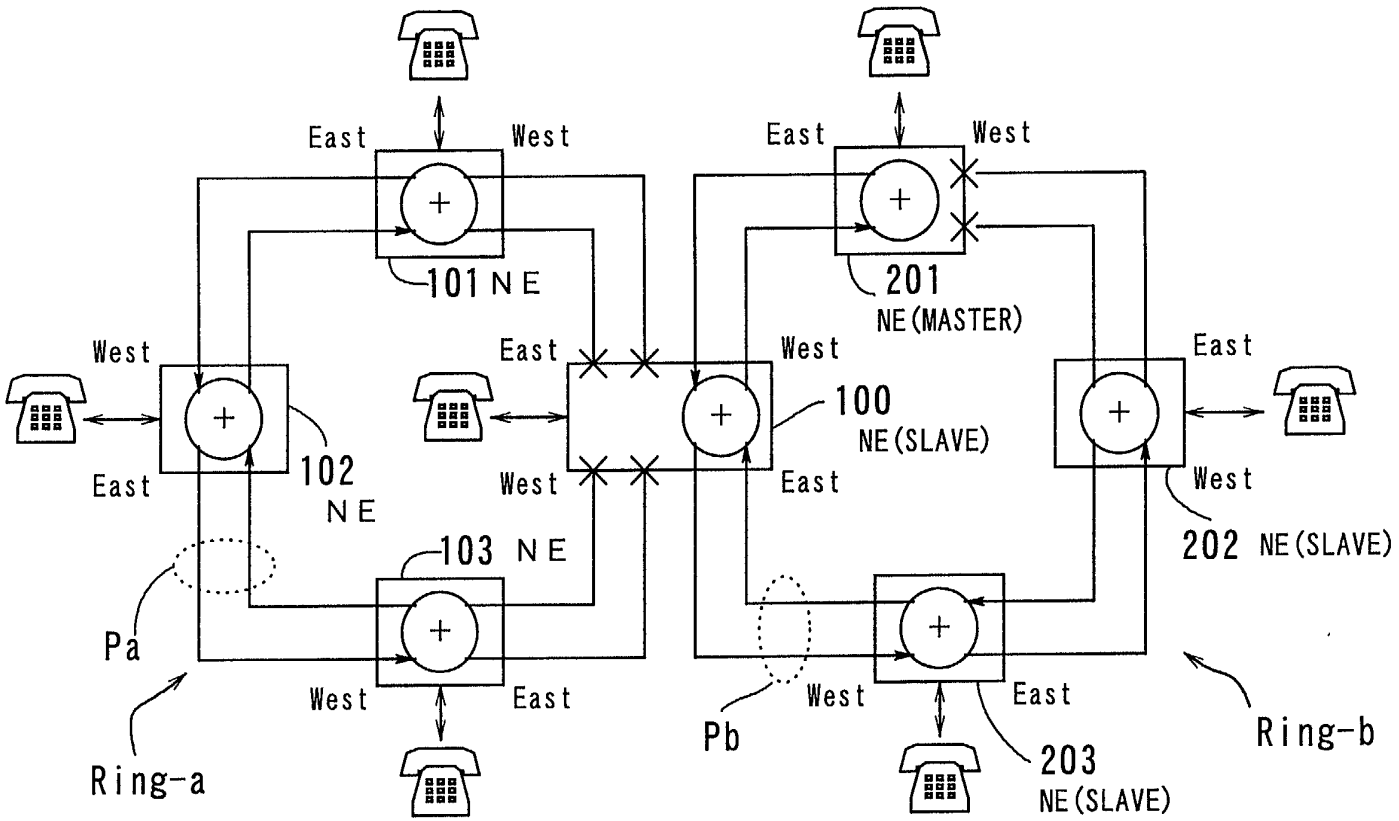


PRIOR ART
FIG. 13



PRIOR ART
FIG. 14

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Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

ORDERWIRE CONTROLLER

上記発明の明細書（下記の欄でx印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ __月__日に提出され、米国出願番号または特許協定条約国際出願番号を_____とし、
（該当する場合）_____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

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私は、米国法典第３５編１１９条(a)-(d)項又は３６５条(b)項に基き下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約３６５(a)項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
11-305027	Japan	27/10/99	☐
			☐

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I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

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(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第１８編第１００１条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*

書類送付先

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United States of America

直接電話連絡先： （名前及び電話番号）

Direct Telephone Calls to: *(name and telephone number)*
Helfgott & Karas, P.C.
(212) 643-5000

唯一または第一発明者名	Full name of sole or first inventor Kenichi HASEGAWA
発明者の署名 日付	Inventor's signature) Date Kenichi Hasegawa July 6, 2000
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国籍	Citizenship Japanese
私書箱	Post Office Address c/o Fujitsu Digital Technology Limited, 3-9, Shin-Yokohama 2-chome,
	Kohoku-ku, Yokohama-shi, Kanagawa 222-0033, Japan
第二共同発明者	Full name of second joint inventor, if any Koichi SUZUKI
第二共同発明者 日付	Second inventor's signature Date Koichi Suzuki July 6, 2000
住所	Residence Kawasaki-shi, Kanagawa, Japan
国籍	Citizenship Japanese
私書箱	Post Office Address c/o FUJITSU Limited, 1-1, Kamikodanaka 4-chome, Nakahara-ku,
	Kawasaki-shi, Kanagawa 211-8588, Japan

（第三以降の共同発明者についても同様に記載し、署名をすること）

(Supply similar information and signature for third and subsequent joint inventors.)

THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: **Kenichi HASEGAWA et al.**

Filed : **Concurrently herewith**

For : **ORDERWIRE CONTROLLER**

Serial No. : **Concurrently herewith**

August 22, 2000

Assistant Commissioner of Patents
Washington, D.C. 20231

SUB-POWER OF ATTORNEY

S I R:

I, Samson Helfgott, Reg. No. 23,072 attorney of record herein, do hereby grant a sub-power of attorney to Linda S. Chan, Reg. No. 42,400, Jacqueline M. Steady, Reg. No., 44,354 and Harris A. Wolin, Reg. No. 39,432 to act and sign in my behalf in the above-referenced application.

Respectfully submitted,

Samson Helfgott
Reg.No 23,072

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